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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 63.

CARE OF MILK ON THE FARM.

BY

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(Revised by the author, September, 1906.)

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., September 19, 1906.

SIR: I have the honor to transmit herewith and to recommend for publication the accompanying revision of Farmers' Bulletin No. 63, entitled "Care of Milk on the Farm," by R. A. Pearson, M. S., professor of dairy industry at Cornell University. The original paper was written by Professor Pearson in 1897, when he was assistant chief of the Dairy Division of this Bureau. The previous editions having been exhausted, it has become necessary to reissue the work, and it has accordingly been revised and brought up to date for this purpose.

Respectfully,

A. D. MELVIN,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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INTRODUCTION.

IMPURE MILK UNPROFITABLE.

Everyone who handles milk realizes that it is a perishable product and requires special care. Those who deal in milk or use it in the manufacture of other products well know that its value depends upon the care it has received more than anything else. Prosperous dairy farmers recognize these facts and act accordingly. The failure of many others can be traced to their disregard of these same facts.

In an endeavor to ascertain the most important drawbacks to successful dairy work, as viewed by men engaged in different branches, a large number of inquiries were sent out from the Dairy Division to dairymen, butter and cheese makers, and milk dealers in all parts of the country, asking them to state what feature of dairying, in their judgment, was in greatest need of improvement. The following are some of the many replies received:

The delivery of milk by patrons and the proper care of it prior to delivery. Frequently milk is refused on account of its advanced decomposition. (From the manager of a creamery.)

The care and handling of milk on the farm and until it gets to the creamery. (From a butter maker.)

The careful handling of milk and its delivery to the factory in good condition. (From the salesman of a cheese factory.)

Care and handling of milk before it gets to the creamery or cheese factory. (From an operator of a factory.)

Taking care of the milk before it gets to the creamery. (From a farmer.)

Handling the milk from the time it leaves the cow until it is put onto the train. (From a milk dealer.)

These persons and many others in similar positions can tell how dairy farmers suffer losses probably amounting to many millions of dollars annually because they allow good milk to deteriorate in their hands. Neither good butter nor good cheese can be made from spoiled milk, and the retail market does not want such milk.

Very few replies referred to the chemical composition of milk or to the amount of butter fat it contained. Milk that is poor in fat nat-

urally, or because it has been adulterated by skimming or watering, need not now give the butter or cheese maker much concern. Since the introduction of the fat test there is no strong temptation to water or skim the milk wherever the system has been adopted of paying for it on the basis of the amount of fat delivered instead of for the bulk of milk.

In answer to the many statements received like those quoted above, and in answer to numerous inquiries on the subject, an attempt is here made to explain the most common ways in which milk is contaminated, and how to keep it pure. Reference is made to winter as well as to summer dairying, because the former is rapidly developing and already has become of great importance in some sections.

It needs to be said with emphasis that it is to the interest of every milk producer to have the best milk possible. Such milk is always worth more than that carelessly produced, for whatever purpose it is used. But when a dairyman is delivering his milk to a factory where it is mixt with the milk from other dairies, then it is his plain duty to his neighbors as well as to himself to furnish the best milk that he is able to. If he delivers a bad lot of milk and it is accepted it may spoil the entire production of the day and thus decrease the returns to every patron. Such conduct would be even worse than skimming or watering the milk, and there is no doubt that the losses caused by spoiled or tainted milk delivered to factories greatly exceed those due to both skimming and watering.

It is unfortunate that it has not yet been found practicable to base payments for milk upon its sanitary condition as well as its fat content. So long as this is not done operators of factories are justified in strictly refusing to accept any milk in poor sanitary condition. In fact, they must do this in justice to themselves and to the patrons who deliver good milk. In contracts and agreements the words "pure milk" ought to be taken to mean milk that not only has a normal chemical composition, with fat and total solids above the legal limit, but that is also wholesome and free from all unnecessary contamination.

Special knowledge is necessary in conducting dairy work the same as it is in other occupations. When one understands something of the science underlying successful dairy work many of the changes which milk undergoes cease to be mysterious and are found to be easily understood and controlled.

BACTERIA.

When left to itself, under ordinary conditions, animal and vegetable matter sooner or later undergoes a change; these changes are familiar to most persons as decay, decomposition, putrefaction, or rot. The

most common change of this kind in milk is souring; but there are other changes or fermentations, all of which were once supposed to be due to ill health of the cows, to foods eaten, to thunderstorms, etc. It is now known that changes of milk and other organic matter are caused by very small vegetable organisms called germs, micro-organisms, or bacteria. Different forms of these little creatures produce different effects—useful, harmless, or objectionable. A few, known as pathogenic bacteria, produce disease in their host.[a] Bacteria are abundant in nature, and manage in some way to get onto most organic substances; they are able also to effect an entrance into such substances, excepting the tissues of living and healthy animals and plants.

Many persons think of the term " bacteria " as relating to a disease of some kind; they fail to appreciate that among these micro-organ-

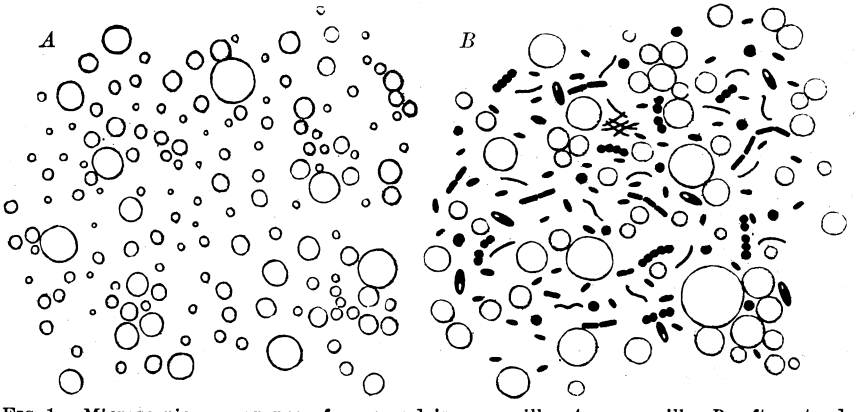

FIG. 1.—Microscopic appearance of pure and impure milk: *A*, pure milk; *B*, after standing in a warm room for a few hours in a dirty dish, showing, besides the fat globules, many forms of bacteria. (Moore.)

isms man has friends as well as enemies. They are great scavengers, and they have a most important connection with agricultural processes; in the manufacture of certain products their action is depended upon almost entirely; they are absolutely necessary in the making of fine butter and are useful in giving variety to cheese.

DESCRIPTION OF BACTERIA.

Bacteria are so small that it is difficult to form a conception of their size; it would require many hundreds of them in a continuous line to extend an inch. A thousand billion of them, if placed together, would weigh but a small part of an ounce. In a single drop of badly

[a] The term " host " is applied to the subject infested, whether animate or inanimate.

infected milk the bacteria may be counted by the million; it is therefore evident that they can be seen only when highly magnified. (Fig. 1.) Bacteria are not all of the same size nor the same shape, nor do they all grow alike under the same conditions. Their differences in these respects aid in classifying them.

They are composed of a single cell, and the most common way by which they reproduce themselves is by the division of the "parent" cell into two smaller cells. This is accomplished by the bacterium gradually becoming more and more constricted about the middle until it separates into two parts; these increase in size, and the process is constantly repeated. Under favorable conditions multiplication takes place with great rapidity. A bacterium may develop and be ready to reproduce itself in less than half an hour.

Another form of reproduction of bacteria is by spores. These correspond to seeds of plants, and are usually formed under circumstances not favorable to the continued development of the bacteria and their multiplication by division. Like the seeds of wheat, the spores can endure conditions which would be fatal to the growing form, and after surviving such conditions they quickly develop when more favorably situated. Some spores have been found to retain their powers of germination for more than ten years.

CONDITIONS AFFECTING BACTERIAL GROWTH.

Three things are essential for the growth and development of bacteria—they are food, warmth, and moisture—and when these are furnished, as they are to a greater or less extent in every dairy, the multiplication of bacteria takes place. Some species require other conditions besides those named; certain ones must have access to air, while others can not thrive in the open air; some require to be in an acid medium, but to most species a medium having a neutral or alkaline reaction is preferred; darkness is requisite to some and liked by most species; their growth is checked by bright light, and direct sunlight is fatal.

The food elements required by bacteria are present in the constituents of milk, and they are in a readily available state. Nitrogen, carbon, oxygen, and mineral matter are essential and are furnished by the casein, albumen, milk sugar, and mineral salts. The butter fat is of little importance as a food for germs.

Bacteria thrive within wide limits of temperature. Some species do best at a high temperature, near blood heat, while others prefer a lower temperature. Every person who has handled milk knows that if kept a long time in a cool place it undergoes quite a different change from that which takes place at a high temperature. The reason for this is that different degrees of heat are favorable to dif-

ferent species of germs. The species favored rapidly increases and covers up the work of others less favored, but which may continue to grow slowly. The degree of heat has an important effect also on the rate of growth of bacteria. At about 90° F. most forms grow with great rapidity, the rate of their multiplication decreasing with the decrease of temperature. Bacteriologists have shown that at 93° F. certain germs may increase in number in four hours more than two hundred fold, while at 55° F. their increase is only about eightfold. An experiment is reported in which a difference of 18 degrees in the temperature of two samples of milk caused, in fifteen hours, a difference of almost 75,000,000 bacteria per cubic centimeter.[a] This shows very plainly how much the rate of growth of bacteria depends upon temperature.

At 50° F. most bacteria are quite inactive, but at this and considerably lower degrees of temperature they retain life, and some forms continue to multiply. Freezing does not kill them. Some species can withstand a temperature many degrees below zero, and with the return of suitable conditions again commence to grow.

Up to a certain point the higher temperatures have the same effect as cold, i. e., make the germs inactive. But when the heat is raised to about 125° F. some are killed; others, not harmed by this temperature, are destroyed by greater heat. A sufficient temperature to kill almost all of the growing forms found in milk is 150° F. for ten or fifteen minutes. Spores require still more heat; some can withstand boiling temperature, 212° F.

If milk is heated high enough to kill all the growing forms of bacteria and then suddenly cooled to a low temperature to prevent the development of spores it will keep sweet a long time, because it is free from active germs. It must be quickly cooled, however, or the spores will develop while the temperature is ranging from 110° down to about 60°, and the bacteria thus formed may continue to increase slowly after the cooling is completed. When milk is heated for the purpose of killing bacteria (the process is called pasteurization or sterilization)[b] it must, for best results, be held at the highest temperature at least several minutes, as some forms are not killed by a short exposure to a temperature which is fatal to them in a longer exposure. In dry air much higher degrees of heat than those named are necessary to kill bacteria. For this reason steam is generally used instead of dry heat for sterilizing utensils.

Bacteria also require moisture. It is well known that dead organic

[a] One centimeter is about the same as two-fifths of an inch, and a cubic centimeter is about equal to half a thimbleful, or fifteen drops.

[b] Strictly speaking, sterilized milk is sterile, meaning free from living organisms; pasteurized milk is partially sterilized, or free from most organisms.

matter quickly disintegrates when it is in a moist condition and the changes are arrested when it is dried. Milk being a fluid, all the moisture that is necessary for micro-organisms is at hand. There is no danger of food being too dilute for bacteria; some forms do well even in comparatively pure water. Germs seem to find ideal conditions in milk.

The chief agents that are antagonistic to bacterial increase are, together with light, the opposites to the first three favorable conditions mentioned above, viz, lack of food, extremes of temperature, and dryness. These are the dairyman's most important weapons, and when he has learned to use them properly he need have no fear of milk souring too soon or being otherwise affected by germs. The operator of a creamery or factory is also sometimes able to take advantage of the fact that certain species of bacteria are antagonistic to each other and can not grow well together if they are in the milk at the same time. In such a case there is a battle for existence; the kind having the smaller number to start with, or being less favored than the other by temperature or other conditions, is usually overcome. Thus one can at times cut off the effects of undesirable bacteria by giving advantages to other desirable or harmless forms that are hostile to them. This is what takes place when the butter maker adds a "starter" to his cream and ripens it at a high temperature as rapidly as possible to prevent the increase of a taint which he may discover in the milk. A starter is a preparation, or culture, containing large numbers of the peculiar kind of bacteria that ripen cream; by its use proper forms of fermentation are started and assisted in milk or cream.

When micro-organisms are growing, new products are formed from the constituents of the medium by which they are surrounded. For example, the lactic-acid bacteria, which are the most numerous about a dairy, cause milk to sour by changing the sugar of milk to lactic acid. Other kinds of bacteria produce other products of growth. After a certain amount of acid or other product of growth has been developed, some bacteria can not longer thrive; the surroundings are so changed by their own operations that they cease to increase. This fact, however, is not of much practical value to the milk producer; the fermentation of his milk should never be allowed to proceed so far that it stops itself.

Bacteria cease to grow in the presence of certain chemicals. When these are added to milk they are known as preservatives; when they are used for such purposes as killing the germs in or about a dairy they are known as disinfectants. Both of these will be referred to later.

DAIRY BACTERIA.

The greatest number of bacteria are to be found where their food is most abundant. Animals, feed, manure, soil, and milk are all hosts, or breeding grounds, for bacteria. For this reason the dairy is a place where myriads of germs of different kinds are to be found.

NUMBER OF BACTERIA IN MILK.

Milk ordinarily contains large numbers of bacteria. It is one of the few substances that are adapted to almost any species, and when a few only have once obtained an entrance it quickly becomes inhabited with large numbers. There may be from a few hundred to many million in a single drop, depending upon its exposure or contamination and the time and opportunity the germs have had for increasing. Dirt in milk is a sure sign of large numbers of bacteria. As a result of their struggle for existence, frequently a smaller number of species are in milk after it has stood than when perfectly fresh, altho the number of *individuals* may have greatly increased. As the rate of increase is influenced by temperature, the number present at any time also depends upon the previous temperature of the fluid. City milk commonly contains from 50,000 to 1,000,000 bacteria per cubic centimeter, some samples not infrequently containing several million germs. The best milk sold in cities and towns contains less than 10,000 bacteria per cubic centimeter.

The number of bacteria in a sample of milk is an indication of its purity, but not an absolute proof that it is or is not of good quality. Large numbers of harmless bacteria are sometimes found in good milk. It is the harmful ones, and those that are liable to become harmful if present in too large numbers, that chiefly concern the dairyman. If the latter are kept out of the milk, or if their growth is controlled, the number of harmless ones will also probably be reduced, for the measures which restrict one class have a like effect on the other. On the other hand, whenever large numbers of harmless germs are found there is probability that harmful forms are included.

KINDS OF DAIRY BACTERIA.

Scores of different kinds of bacteria have been found in milk and its products, new and old. Many of these have not been completely described and will require much more study before their characteristics are fully understood. Different sources of contamination contribute different types of bacteria to milk, and the large number of forms does not seem strange when their many possible sources are studied. One would expect to find a difference in the kinds as well as in the numbers of bacteria in milk of cows kept on pasture and

milked in the open air as compared with the milk of cows continuously stabled. Such is the case. Especially is this true in regard to the germs of manure, which are more abundant in the stable than out of doors.

For practical purposes, dairy bacteria may be separated into three classes, as follows: (1) Harmless bacteria; (2) useful bacteria; (3) harmful bacteria.

(1) Harmless bacteria.—These are the most numerous of the forms found in milk. They are of comparatively small direct importance to the milk producer, but they are not in milk when first secreted, and, as suggested above, if they obtain entrance to it they are evidence that other germs also have had an opportunity to plant themselves.

(2) Useful bacteria.—Some forms of bacteria are essential to dairy operations. Good flavor in butter depends upon several conditions, but one of the most important is the action of bacteria which, in the process of maturing or ripening, produce the desired aroma and flavor. Cultures of bacteria for this purpose are now regularly sold on the market. Similarly, some of the differences between varieties of cheese are caused by the kinds of bacteria that grow in them. Bacteria needed in some cases are not wanted in others, so the same species which are useful at one time may be harmful at another time.

(3) Harmful bacteria.—These form the most important class. They may be subdivided into two groups, viz, those having an injurious effect on the milk, and those apparently not affecting the milk but having an injurious effect on the health of the consumer. Many species fall in only one of these subdivisions; others belong to both.

Certain bacteria may be indirectly injurious by producing conditions favorable for other germs which are directly injurious, but not able to grow in milk until its nature has changed. For example, a species which causes bitter milk is said not to thrive until the ordinary sour-milk (lactic-acid) germs have developed some acidity. It is not necessary to go into details as to the many different changes produced directly and indirectly by numerous forms. Some are troublesome whenever they find their way into the milk, others become a nuisance only when they are present in very large numbers. Types that color the milk, form gas, or produce disagreeable flavors are always objectionable. Farmers' Bulletin No. 29 treats more fully and technically of the bacterial changes of milk. The bad effects of those bacteria which produce a pronounced change in milk are usually confined to the milk itself. Its change is so marked that it is rarely used as food.

Some bacteria thrive in milk and do not have a marked effect on it, but may cause disastrous results to the consumer. These include

germs of disease and should be most carefully guarded against. Good proof exists of the transmission of several diseases by milk, and in a number of instances epidemics have been traced to an infected milk supply.

Another kind of bacterial action which may indirectly result in injury to health is referred to by Conn. He states that some of the common milk bacteria may be present in such great numbers as to produce poisonous toxins " which are directly injurious to the weak stomach of the infant or of the invalid." Many cases of cholera infantum and similar troubles are evidently due to this cause.

So far as known, excessive numbers of any form of bacteria are objectionable in milk that is to be consumed as food in its natural state, and, indeed, most forms are undesirable in milk that is to be manufactured.

HOW MILK BECOMES IMPURE, AND METHODS OF PREVENTION.

Knowing something of the nature of bacteria and their abundance in milk, natural questions of interest are, How do they get into milk? and, How can they be kept out of it?

This is an unpleasant subject when lookt at from its worst side. But methods of producing milk are constantly being improved, and it is really an attractive subject to one who makes a study of it. Improvements are being worked out by the experiment stations and in hundreds of dairies that are supplying milk to well-conducted creameries and cheese factories or sending it to towns and cities where there is a demand for superior milk. The " certified-milk " dairies deserve much credit for devising improved methods of handling milk.

Ninety-five per cent of the contamination of milk occurring under ordinary circumstances can be avoided by taking care to eliminate all possible sources of impurity and conditions favoring germ growth. The fact that bacteria are usually attached to larger bodies such as dust and dirt makes the work of preventing their entrance into milk comparatively easy. And the fact that their increase is promptly checked by low temperatures makes it a comparatively easy matter to hold milk in good condition a reasonable length of time even if some germs have succeeded in getting into it.

Fighting dairy bacteria becomes expensive when it is carried to the point where the milk will contain only a few hundred or a few thousand germs per cubic centimeter. This extreme, however, is not advised for the great bulk of the milk business where extra prices can not be obtained. The measures advised below are not extreme, tho they may be carried to that point, as everything else can be overdone. By their reasonable observance the ordinary contamina-

tion of milk can be enormously reduced—probably 75 per cent—without any additional cash outlay, and it can be reduced a further 20 per cent with an additional cash outlay of perhaps 1 cent a quart. Still further reduction of contamination costs far more in proportion.

The different steps thru which milk passes might be compared to the links of a chain—if one is weak the strength of the whole chain is impaired; so, if the care of the milk is neglected at any step, the care taken at other times may be rendered useless.

The causes of and remedies for impure milk will be discust under five heads:

I.—Health of the herd and its protection.

II.—Cleanliness of the cows and their surroundings.

III.—Construction and care of the utensils.

IV.—Employees—their health, cleanliness, and methods of milking.

V.—Handling the milk.

I.—HEALTH OF THE HERD AND ITS PROTECTION.

Method of Contamination by Disease Germs.

Contamination of milk by the germs of disease is the most dangerous form. Some infectious diseases attack animals and man alike, and if a cow is suffering with one of these she is a menace not only to the whole herd but to persons who consume her product, for her milk may readily act as a carrier of germs to the consumer. It has been found that in certain diseases, especially when the udder is affected, the germs may be in the milk at the time it is drawn, in which case no amount of protection after milking will assure freedom from disease-producing bacteria.

Tuberculosis, or consumption, is the disease that is most common and most to be feared. Much has been written on this subject, and it is unnecessary to discuss here the particular conditions that cause the malady or aid its progress. When a cow is in the advanced stages of tuberculosis the milk becomes unnatural in appearance, but sometimes even before the udder is known to be affected it may contain numbers of the specific germ called *Bacillus tuberculosis.*

An English authority holds that diphtheria may similarly be transmitted from the cow to the milk consumer, and this seems to be true of scarlet fever, or a closely allied disease. Foot-and-mouth disease and anthrax are some of the others that may infect milk. It is fortunate that when the animal is affected with some of these dangerous diseases the milk flow soon stops. It is also fortunate that some of these diseases do not occur. or are very rare, in this country.

Abnormal Milk and Slight Variations.

Other factors than bacteria may influence the appearance and composition of milk at the time it is drawn and render it impure or unnatural. The cow's health is an important factor, but abnormal milk is due also to excitement of the cow, temporary disorder, bad treatment, injury, time from calving, and substances eaten. Any of these causes may seriously affect the quantity as well as the quality of milk. Some of them are responsible for sudden slight variations in the quality of milk, as shown by the regular tests, and which frequently seem so mysterious and without cause.

When a cow is diseased she may continue to give milk, but it is liable to be abnormal in composition. The fat may be reduced to a quarter of the usual amount, so that the milk appears skimmed, or the fat may be abnormally increased. Being " in heat " or " off feed " may have a similar but less marked effect.

Excitement of the cow affects the milk; even changing the stall may slightly alter its composition. The cow is an animal of regular habits. She expects to be milked at a certain time and to be fed at a certain time, and becomes more or less uneasy if the usual program is not carried out. A change of milkers may result, for a few milkings, in a reduced yield, unless the cow has become accustomed to having different milkers.

Many slight variations in the quality and quantity of milk may be charged to neglect. The farmer who leaves his cows out in a bleak storm should not be surprized to find that his test at the factory has fallen, while that of his neighbor whose cows were sheltered did not fall. One of the first functions of food is to maintain the bodily heat, and when necessary it will be used in this way instead of forming milk. The brutal treatment of a cow by kicking, beating, fast driving, or otherwise, is not without effect on her milk. Bloody milk is often caused by an injury to the udder. Sometimes the " boss of the herd " is to blame for such injuries to the weaker animals.

The natural variation of milk due to the time since calving is, of course, unavoidable; it is so gradual and so slight that sudden changes can not be attributed to this cause. The first milk given after parturition is known as colostrum. It contains an excessive amount of albumen, and its other constituents are not in the same proportions as later. Colostrum is unfit for use except as food for the young calf. Within a few days the milk becomes natural. It gradually grows richer in fat during the last few months of the period of lactation.

The proper time for commencing to use milk after calving is easily decided by its appearance and taste and its behavior when boiled. Colostrum contains much more albumen than normal milk, and this coagulates into a solid mass when heated.

The influence of feed upon the quality of milk is a subject which has received much attention. Feeds may have some effect on the quality of milk produced, but it is not as marked as supposed by many; the breed and individuality of the cow are of far greater importance. Slight variations in composition may be caused by a sudden change of feed, and milk is sometimes rendered disagreeable by taints caused by the cows eating turnips, onions, garlic, sour ensilage, ragweed, or other strongly flavored feeds or weeds.

Remedies.

As the first requisite for pure milk is healthy cows, any animal suspected of being sick or out of condition should be immediately separated from the herd and not allowed to remain near the dairy. If the milk from such animals is used it must first be boiled. On every dairy farm there should be a proper place for keeping sick or suspected animals. It is absurd to claim that any large herd can be constantly maintained in perfect health, and when one finds a dairy farm with no provision for the care of sick animals, he has good cause to suspect that the milk from that place can not be relied upon for its purity.

When a herd is known to be sound, every precaution should be taken before adding new animals. In one case carelessness in this respect resulted in the loss of about 100 cows that had been in good health until a few fresh milkers, supposed to be also healthy but later proved to be tuberculous, were introduced into the stable. The tuberculin test has proved to be a reliable means of detecting the presence of tuberculosis, and its use in any suspected herd is advisable. It does not injure the animals and may be the means of finding cases that could not otherwise be found but which yet might be a source of infection to sound animals. It should be applied by a competent veterinarian, and after a herd has been tested no animals should be added to it unless known to be free from the disease.

There is little danger of a healthy cow giving abnormal milk if she is well cared for and not allowed to be excited or unnecessarily disturbed. For this reason it is customary to have certain attendants always care for the same animals. But on some large dairy farms this practise is not followed, the claim being made that cows are satisfied with any attendant as soon as they become accustomed to frequent changes. No dog, unless it has been well trained, should be allowed in the pasture or barnyard, and the herd should never be driven rapidly to or from the pasture. If a cow is in the habit of hooking others she can usually be quieted by dehorning.

Bad effects of changing feeds may be avoided by changing them gradually. Those feeds which give flavor to the milk should not be

used, but if they must be used, the best time is soon after milking. Cows may safely be allowed to graze in a pasture containing some garlic if they are stabled several hours before milking, and given dry feed. Such articles as turnips, onions, sour ensilage, etc., should not be stored in the stable, as their odor is imparted to milk thru the air.

The importance of good water for cows to drink is so evident that it hardly seems necessary to mention it.

II.—CLEANLINESS OF THE COWS AND THEIR SURROUNDINGS.

The Effect of Poor Methods and Equipment.

The largest part of the impurities found in milk get into it in the short time after it is drawn from the cow and before it leaves the stable. This brief period may be called the critical time in the history of dairy products. In many stables myriads of bacteria are entering the milk every minute it remains exposed, being carried there by many kinds of foreign matter, some of which would do no harm were it not for the germs they bring. Grotenfelt mentions the following impurities which he found in unstrained fresh milk: Manure particles, fodder particles, molds, fungi, cow hairs, particles of skin, human hairs, parts of insects, down from birds, small bits of wood, woolen threads, linen threads, fine threads, soil particles. It is evident that these different kinds of foreign matter are derived from numerous sources, but the bulk of the impurities consists of ordinary stable dirt, chiefly manure, and its presence in milk is evidence of slovenly methods. Over 50 grains of this matter have been found in 100 pounds of milk, and when it is remembered that it contains myriads of bacteria of the forms causing putrefaction and decomposition, it does not seem strange that milk is soon affected by its presence. Germs introduced in this way, in large numbers, may act as poisons to the delicate consumer and cause severe intestinal troubles.

Dirt gets into the milk when in the stable, principally from three sources, viz, the cows, the milkers, and the air. But this classification is unnecessary for stables which are carelessly cleaned only once or twice a week, and in which it is impossible for an animal or person to remain any length of time and come out undefiled; in such places there is a constant shower of bacteria.

Exterior and interior views of buildings where the production of pure milk would be impossible are shown in figs. 2 and 3. Any building rapidly going to ruin would fall in this class, but the illustrations show new structures especially erected for dairy purposes. The small building at the right in fig. 2 is the dairy house. Note the general appearance of shiftlessness about the buildings and the ab-

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sence of windows or other provision for light and ventilation. The pails, cans, and strainers are left in impure stable air, and the dairy house is supplied with air which has just past over heaps of manure. Many stables are so dark that it is impossible even at midday to see one's way in them, and they are so close that it is a relief to get out into the fresh air after being inside for a few minutes.

Dirt from the Cows.

The cows supply most of the dirt which gets into milk, as anyone will admit if he is at all familiar with the conditions in most stables.

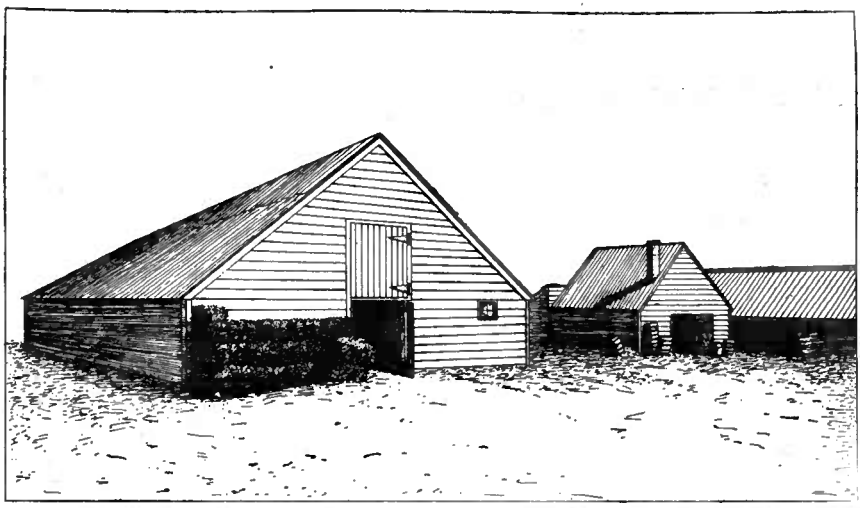

FIG. 2.—Cow stable and dairy house improperly located and constructed, and poorly cared for.

It is not uncommon to see cows covered with so much dust that the color of their backs can not be seen; and their flanks, hips, and sides are sometimes plastered with layers of manure.

When the work of cleaning the cows is neglected, it is impossible to keep milk even decently clean when milking. Large lumps of dirt, hairs, and straws are continually falling into the pail. The hairy coat is an excellent harbor for dirt and bacteria, and every time anything touches the skin or the udder, or the surrounding parts are disturbed, a dirt shower is precipitated. As more or less violent motion always occurs at milking, the loosely adhering particles are dislodged just at a time when the milk pail is in a position to collect them.

Dust-laden Air.

Air is a source of germs found in milk. It is not a medium capable of supporting bacteria by itself, but it carries more or less of small particles of dust and organic matter in suspension, and these have

many bacteria in and upon them. On account of the dust constantly being raised the number of organisms in the air of a stable may be considerable, especially if dry feedstuffs are used and the manure is allowed to become dry on the floor. Over 100 different kinds of organisms have been found in a single quart of stable air. These do not increase in numbers while floating about, but they quickly commence a vigorous growth when they fall into fresh warm milk. As dust is constantly tending to settle, the largest number of bacteria is to be found near the floor, and a vast number may fall into a milk pail or can in a very short time.

In some cases stable air contains so much dust, and milk is exposed to it so long, that it is the chief means of contamination. Most of the

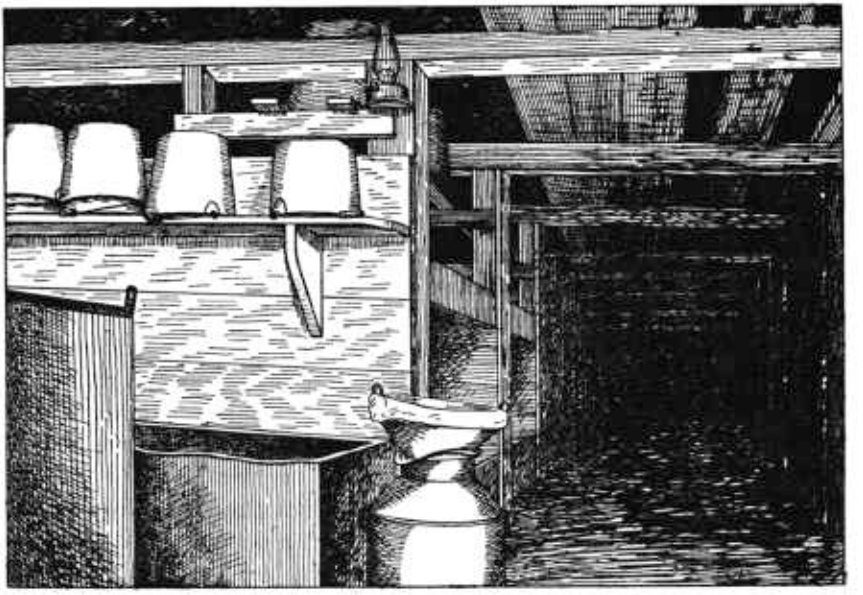

FIG. 3.—Interior view of an insanitary cow stable.

dirt in the air is from dry, dusty fodder and bedding. When hay is thrown down thru chutes the air is quickly filled with dust, and air currents and the constant shaking of the hay by the animals keep the dust from settling. Some rises every time the bedding is disturbed, thus it is most abundant beneath the cow during milking.

Keeping the Cows Clean.

Every milch cow should be curried and brushed *daily*, and the udder and lower parts should always be wiped with a damp cloth just before milking, for the purpose of moistening the dirt and bacteria to prevent their being shaken off during milking. Animals not accustomed to this care may object to it at first, but with gentleness

and patience on the part of the attendants they soon learn to expect it and to stand quietly during the operation, which contributes to their own comfort. Some dairymen groom their cows as carefully as horses are groomed in the best stables, their coats are kept smooth and shining, and one need never fear soiling his hands by touching them.

A stiff open brush does good work in removing dry matter, but it should not be used just before milking because of the large amount of dust that it throws into the air. Stocking has shown that milk can be contaminated in this way more than if the cows were not brushed at all. Soft and damp manure should be scraped from the hips and flanks, and when necessary this should be followed by a washing, or repeated washings. Washing or wiping the udder, or in any way agitating it before being ready to draw the milk, is objected to by some milkers, who believe that this action makes the cow think she is to be immediately milked, and when the attendant returns half an hour later the usual amount or quality of milk is not obtained. But many practical dairymen make a regular practise of cleaning all the udders before milking is begun and notice no bad effects. Evidently the cows become accustomed to the cleaning and learn not to expect to be milked until the milker appears with the pail. Care should be taken not to make the parts too wet, or the impure water will drip into the pail; they should be only slightly dampened. It is also necessary to use care lest the cow take cold from this wetting. The work of cleaning may be lightened by having the hair clipt about the udder and on the flanks and by the use of clean bedding, not too fine. A light chain or rope stretched across the stanchion under the cow's throat will keep her standing between the time of cleaning and milking. (Fig. 4.)

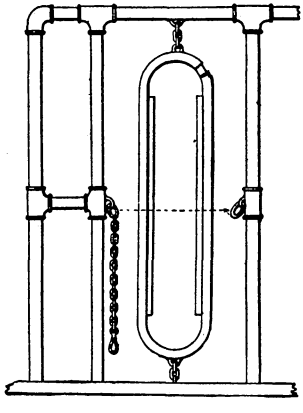

FIG. 4.—Chain on stanchion frame (or stanchion) to pass under the neck when desired to keep cows standing after being cleaned and before being milked.

The herd requires the most attention when continuously stabled. But it is almost as necessary to clean the animals when pastured as at other times, especially if they are permitted to wade in slimy pools. Wading in clean water is not objectionable, but cows should always be kept out of foul or sluggish water.

The barnyard ought to be so well drained that stagnant pools of water are never seen there. If this is impossible, the pools should be fenced to keep the cattle out.

The Clean Stable.

Contamination of milk from stable air can be largely avoided by using special care in feeding and cleaning. The air should not be full of dust at milking time. No dusty food should be fed just previous to milking. If it is believed to be necessary for the cows to be eating at milking time, they may be given a moist feed then and the dry fodder used after milking. The animals and stables should be cleaned early and the stable well ventilated before milking is commenced. In the morning it is better to milk before cleaning the stable than *immediately* after cleaning when the air is full of dust and odors. In a light, dry building, in hot weather, it is well to sprinkle

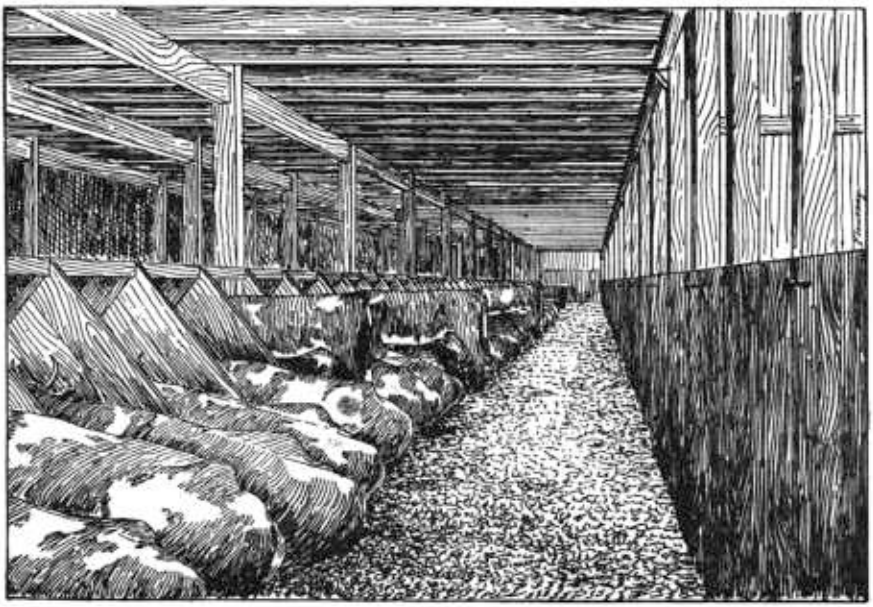

FIG. 5.—Stable in which shavings are used for bedding.

the floor to settle the dust and lower the temperature. Some advocate the use of a special room for milking only. But this has not yet proved to be practicable. The effect of milking in pure air is shown by an experiment in which a cow was milked in an open field on a damp morning when the air was clear, and it was found that her milk contained only a few bacteria in the same volume which, under ordinary conditions in the stable, contained many hundred.

Moldy hay or straw must not be used for bedding cows, as the special bacteria which they carry are liable to produce harmful changes in the milk. Clean straw or new shavings make the best bedding. In many places dry shavings (fig. 5) from planing mills

can be obtained at reasonable cost; in some cases they are in such demand for this purpose as to be baled, shipped, and sold for four or five dollars a ton. Coarse stuffs for bedding are unsatisfactory, as they are usually poor absorbents and are uncomfortable for the animals, besides being difficult to handle. No sensible dairyman will attempt to economize by using the refuse from the horse stalls for bedding cows. Clean sand is found to be a fairly good absorbent, but, like sawdust, it gets into the hair and makes extra work in cleaning.

If the cows are kept continuously in their places, an attendant should pass thru the stables several times a day and remove droppings. When the herd is large, a boy or man may well be continuously employed for this purpose. This is more necessary than formerly, on account of the high feeding usually practised and the consequent soft manure and disagreeable odor. It is well to make free use of land plaster for the purpose of absorbing moisture and undesirable odors as well as increasing the value of the manure.

At certain periods, depending upon the thoroness of the daily work and the quality of milk desired, the stables should be given extra careful cleanings. The following directions may appear formidable, but they call for nothing more than is frequently done in many well-conducted dairies. No nook nor corner should be overlooked. All manure and fodder should be taken out, the four sides and ceiling and floor of every room swept, any rotten woodwork replaced, loose boards secured, dried accumulations about mangers, etc., removed, and the mangers scrubbed with hot water and soap, sal soda, or lye. If the floor is earth, it should be removed to a depth of a few inches and refilled with fresh material. After this work has been done, it is a help to go over the walls, ceiling, floor, stalls, etc., with hot steam direct from a boiler. Such careful cleaning should be followed by a coat of whitewash, which may be applied quickly and satisfactorily with a spray pump. It acts as a disinfectant and makes the building lighter. Care should be taken to have it penetrate all cracks and crevices. Whitewash may be easily made by mixing 60 pounds of water with 100 pounds of quicklime. To each quart of this mixture 5 quarts of water are added. Salt or glue is sometimes used to improve the quality. It should be applied at least twice a year. A receipt for whitewash, recommended by the Light-House Board of the United States Treasury Department, and in successful use for many years, is as follows:

Slake half a bushel of unslaked lime with boiling water, keeping it covered during the process. Strain it and add a peck of salt, dissolved in warm water; 3 pounds of ground rice put in boiling water and boiled to a thin paste; half a pound of powdered Spanish whiting and a pound of clear glue, dissolved in warm

water; mix these well together, and let the mixture stand for several days. Keep the wash thus prepared in a kettle or portable furnace, and when used put it on as hot as posible, with painters' or whitewash brushes.

Disinfection.

When milk has a strong taint at the time it is drawn, the trouble is usually not due to bacteria, and it can be improved by aeration (see p. 32). But when the milk is natural at first and gradually becomes more and more tainted the longer it is held, bacteria are probably to blame, and if the dairy is badly infected with them energetic measures are often required to get rid of them. If the affected milk is not harmful to health, but only objectionable on account of its smell or taste, its entire loss may be made unnecessary by pasteurizing or sterilizing it as soon as possible after it is drawn and before much of a change has taken place, and then using it immediately or keeping it where further infection can not take place. But this treatment does not affect the source of the trouble, and if that is not overcome by sterilizing all utensils and practising scrupulous cleanliness everywhere, the disinfection of the stable, or the destruction of all germs, must be undertaken. Disinfection is also necessary if cattle have been affected with a contagious disease, and it should be done as soon as the last case is cured or removed and before other cattle are added to the herd. While the germs of some diseases are delicate and can live only a short time outside the body of their host, others are hardy and retain their vitality for months or years. Sunlight is a great purifier and should be admitted in abundance. The same may be said of fresh pure air. Both of these aid in disinfection.

Whitewash partially serves the purpose of disinfection; it should soon follow other agents which are employed when more thoro work must be done. Before disinfection, the stable should be carefully cleaned, and any fodder which may have been stored where it was exposed should be destroyed.

Chemical disinfectants are needed for thoro work. Most of these are poisonous and must be handled with great care. The cost is an important consideration in the selection of disinfectants for cheap buildings. The following are comparatively inexpensive: Bichlorid of mercury or corrosive sublimate, in the proportion of 1 part to 1,000 of water, or 1 ounce to 8 gallons of water, is an effective agent. The poison should first be dissolved in a small amount of hot water and then diluted; it may be applied with a brush or as a spray. One pound of chlorid of lime to 3 gallons of water is another effective disinfectant. Carbolic acid is well known; it should be used in the proportion of 1 part to 20 of water.

Sometimes it is best to use a gas as a germicide. In this case no animal nor person can remain in the inclosure being disinfected. It

must be tightly closed so there will be no leaks thru cracks or other openings. When sulfur is burned the building is soon filled with its fumes. A considerable quantity should be supplied and fresh air excluded for twenty-four hours, to give full time for the gas to penetrate into every place where germs may be lodged. Chlorine gas is a more powerful disinfectant. It is generated by chlorid of lime and muriatic acid. The fumes are very deadly, and great care must be taken not to inhale it. Formaldehyde is an efficient germicide which has recently come into use; it is a gas generated by special apparatus. It may also be applied in a solution (formalin).

One of the best and cheapest disinfectants for floors, gutters, waste pipes, etc., is sulfate of iron (copperas). For a floor, as much of this should be dissolved as water will hold; it is then applied with a sprinkler. Lumps of dry copperas are useful for purifying drains.

After a stable has been disinfected it should be allowed to remain empty several days for thoro airing.

Construction of the Stable.

The construction of the stable has an important influence on the health of the cattle which it shelters, the way they are cared for, and the degree of cleanliness that exists. Unhandy, inconveniently arranged buildings are often the cause of much which should be done being left undone; especially is this true of the work of cleaning. The subject of stable construction will not be dwelt on here because it is discust in considerable detail in other publications of the Department. (See Farmers' Bulletin 55 and Bureau of Animal Industry Circular No. 90.) But some of the essentials of a modern sanitary stable may well be mentioned:

Location on elevated ground to provide good drainage.

Abundant sunlight; it should be as well lighted as the dining room of a house.

Abundant ventilation.

Comfortable space and fastenings for the cows.

Feed and milk each to be kept in a separate room apart from the stable.

Smooth, hard floor which will not absorb liquids.

Wide, shallow manure gutters.

Smooth walls.

Dust-tight ceiling.

III.—CONSTRUCTION, CLEANING, AND CARE OF THE UTENSILS.

How Contamination Occurs.

A great amount of milk contamination can be traced to the utensils. Too often their surfaces and corners carry legions of bacteria

to new milk that is put into them. The "cleaning" of pails and cans frequently amounts to only a rinsing in cold or luke-warm water that itself is not clean. In such a case the surface becomes covered with a thin layer of grease and other foreign matter, and a quantity of dirt will be found to accumulate in corners and hidden grooves, especially under the shoulders of the cans. Even careful dairymen are sometimes astonished to find these conditions, which are most likely to occur when the same cans are used for delivering milk to the factory and returning waste products to the farm, or when, for any reason, the work of cleaning is habitually long delayed. Some articles, as coolers, strainers, and strainer cloths, intended to improve the milk, actually do more harm than good because they are themselves dirty.

Some dairy utensils are made of such material or are so complicated or irregular that they are never thoroly cleaned. Wood has so many pores that it is almost impossible to clean it. Old, dilapidated vessels of any kind—those having double bottoms, patches, dents, or bare places from which the tin has been worn—can hardly be cleaned by any practical method.

When impure water is used for cleaning dairy utensils and they are not efficiently sterilized many bacteria from the water remain on the surfaces even after the utensils are dry, and these quickly become active in milk.

Water from cisterns, shallow wells, or streams, or that which has been long exposed to the air, can not be relied upon as pure. It is liable to contain many forms of vegetable life. Sometimes surface drainage, or the seepage from privy vaults or barnyards, finds a way thru the ground to a well, yet the use of the water is continued without knowledge of its dangerous qualities. In this manner water used in a dairy has spread typhoid fever.

When milk is stored in tanks of water the water is fouled by dirt from the bottoms and sides of the cans, by impure ice, by milk slopping over, or by the rinsing of various articles in it. A little of this water may get into the milk by accident or design. Even a few drops are enough to carry great numbers of harmful bacteria.

There is still another way in which utensils may serve to contaminate milk, and this is by bacteria which have fallen with dust upon their clean surfaces between the time of cleaning and using. This source of trouble has shown itself chiefly in certified milk plants where the utensils were perfectly sterilized and then accidentally allowed to accumulate dust, but it exists to a greater or less extent in almost every dairy.

Remedies.

Utensils.—It is a mistake to purchase poor utensils or to keep them after they are badly worn. New cans and pails are frequently the

cheapest means of improving the output of a dairy. In the selection of appliances great care must be taken to get those which are simply constructed and can be easily cleaned. Pails, strainers, cans, and dippers—in fact, everything that comes in contact with the milk—should be well made, and there should be as few places for germs to attach themselves as possible. Vessels for holding milk should be made of a hard, smooth material. Wood is not adapted to this purpose. Many small utensils are now made of prest tin and are free from seams.

The cleaning of every dairy utensil should be done promptly and thoroly, first using cold or slightly warm water for rinsing, then hot water with a cleaning preparation, then clean hot water for rinsing, and finally boiling water or steam for sterilizing. Straining and wiping cloths also require careful attention. Of the special preparations for aiding in cleaning, sal soda or washing soda is one of the best. It would be a convenient arrangement for patrons of a creamery or factory to be supplied with this or some other efficient cleaning agent (not soap) where their milk is delivered; they might also be furnished with brushes, strainers, pails, etc., at cost price at the same place.

Boiling water is a satisfactory sterilizing agent, but heat must be almost continuously applied or the temperature will quickly fall to a point below which bacteria are not killed. Steam is a more effective sterilizing agent, and if there is much of this work to be done a small steam generator will be found useful. If a feed cooker is located close to the dairy, its boiler may serve to supply all the steam that is needed. It is an excellent practise to have cans cleaned and sterilized at the factory, where arrangements for such work can be easily made.

After being cleaned, utensils must be kept in clean places and in pure air. Unless they are protected from falling dust and dirt, they should be sterilized, or at least rinsed in clean water just before using.

Water.—A supply of good water is of the greatest value to a dairy. Spring or well water which comes from a considerable depth is the best, as it is the most free from micro-organisms and is cold. Careful attention should be given to protect the water supply from the entrance of surface water, which is always rich in bacterial life and is especially liable to get into the well or spring during the rainy season. It is also important to make sure that the supply is not contaminated by drainage from buildings. The well should be located at a distance from all piles of filth or other contaminating influences; it is advisable to have the water examined occasionally by a

bacteriologist. State and local boards of health make such examinations. A good way to help keep a well pure is to use from it freely; the water should never be allowed to become stale. Water is not purified by freezing, so if ice has been cut from a stagnant pond or is formed from impure water care must be taken to keep it from coming in contact with dairy products.

The small-top milking pail.—About the most common-sense way of protecting milk from contamination after reasonable precautions have been taken to have the surroundings clean is to use a small-top milking pail. The ordinary milking pail is commonly 14 inches wide across the top, and it is necessarily held in a position to catch most of the dirt and dust that is unavoidably jarred from the cow's udder and flanks during milking. It receives also countless particles of dust, which are always floating in the air of a cow stable. If the diameter of the opening is reduced to 7 inches, then the opening is just one-fourth as large as before and the advantage is obvious.

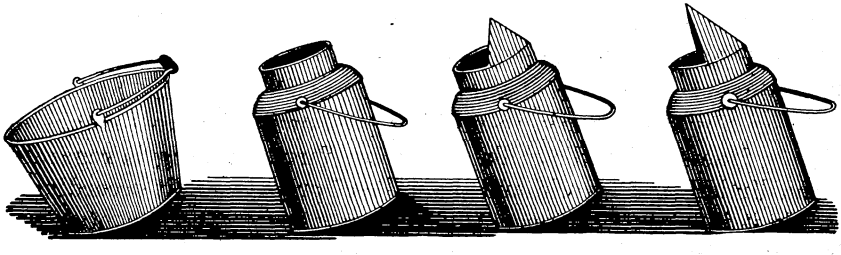

FIG. 6.—The ordinary and small-top milking pails.

Many object that it is not convenient to use a small-top pail, but they would soon find that its difficulties are overestimated. No milker could consistently object to having the opening of his pail only 8 or 10 inches in diameter. Such a pail would be a great improvement over the ordinary one. The size should be governed by the desire to produce clean milk and the patience of the milkers. In some dairies openings of the milking pails are only 5 inches in diameter. As suggested by Dr. Rowland G. Freeman, a visor over the upper side of the opening is a further protection against dirt and dust. (Fig. 6.)

IV.—EMPLOYEES—THEIR HEALTH, CLEANLINESS, AND METHODS OF MILKING.

Human Diseases Carried by Milk.

Milk may be the means of conveying to the consumer germs of diseases from other persons. For example, if any of the attendants have a contagious disease, or are at any time exposed to such, the air

about them and their surroundings becomes more or less infected, and the germs may easily get into the milk in ways described elsewhere.

The most important diseases whose germs enter the milk from external sources are typhoid fever, diphtheria, scarlet fever, cholera, and tuberculosis. Numerous outbreaks of typhoid fever have been reported where there was no doubt about the milk supply being the carrier of the germs, they having gained entrance to it directly or indirectly from persons having the disease—sometimes thru infected water or a person who had nursed or been otherwise exposed to a typhoid-fever patient. Outbreaks of diphtheria have been traced to milk from farms where diphtheria was known to exist in the families of the attendants. The same is reported of scarlet fever and cholera. There is no reason known why tuberculosis may not get into milk and be carried by it the same as these other diseases which originate in human beings.

Untidy Attendants.

Untidy attendants constitute another source from which milk is contaminated. They frequently turn from cleaning the horses, or other equally dirty work, to milking the cows, with no thought of their unfitness to handle milk. On some farms milking is regarded as the dirtiest of all work, and the milkers prepare for it accordingly and do it in a rough manner, which greatly increases the contamination by unnecessarily shaking or throwing dirt into the milk. Dust adheres to the milker's clothes almost as readily as to the cow's coat, and it easily falls from his shoulders and sleeves into the pail; his hands and finger nails also contribute a share to the contamination. Thus he may be the means of conveying to the milk as many kinds of germs as fall from the cow.

Foremilk.

Altho milk is sterile when it is first secreted, it is extremely difficult to obtain sterile milk from the udder, because some germs succeed in finding their way to it even before it is drawn. A few drops of milk are always left in the teat after the milking is done; and the end of the teat remains moist. Germs from the air and from the dirt on the udder or bedding quickly plant themselves in this accessible milk and rapidly increase in numbers. Some work up thru the orifice into the cavity of the teat and milk duct, and those kinds which do not require a supply of air for growth find favorable conditions there, and the milk in the vicinity of the teat becomes contaminated by their increase. Sometimes this form of contamination is quite serious, the first milk, or " foremilk," serving to affect the whole mess.

Precautions.

Contamination from attendants may be easily avoided. A dairyman should know the condition of health of every employee connected with his dairy, and of all the members of their households. If at any time a contagious disease appears, the patient should be excluded from the dairy premises and all communication between the house and dairy should cease until the danger is past. The same care should be taken to keep any person who has been exposed to a contagious disease away from the milk. Those working in a dairy should not enter a house where there has been a contagious disease until it has been properly disinfected.

The attendants should be clean in appearance and in habits. The clothes require special attention. Outer garments, used for dairy work only, should be worn, and they should be cleaned often. If a separate suit is kept for milking and is hung in the stable and never aired, it looks and smells badly and is soon worse than the regular work clothes. White material that can be washt is the best for dairy suits. The objection made against white goods—that they show dirt quickly—is really in their favor. When a suit is soiled it should show it and be cleaned. On model dairy farms the suits are washt daily; this is not a difficult task, as they never become much soiled and they may be rough-dried. A hat or cap should be used, to prevent hairs falling into the pail from the milker's head. If an entire special suit is not used when milking, one loose outer garment at least should be worn. Smoking or any use of tobacco while milking should never be tolerated, and clothing impregnated with the odor of tobacco should be discarded.

Just before milking, the milker's hands ought to be washt. His finger nails should be clean, and they should be kept short and smooth at all times. An abundance of water and soap should be available and used. Some recommend washing the hands after each cow is milked. Care must be taken not to let the hands touch the milk. The hands should be kept dry, and if there are any sores they must be carefully covered before milking. Dirt and milk rubbed into an abrasion on hands or teats cause ugly sores.

Milking is an operation which requires skill, as it has an important effect on the amount and quality of milk given. Dairymen know that there are as great differences between milkers as between cows, and that cows will do much better with some milkers than with others. Indeed, good cows are often almost ruined by poor milkers.

The milker should avoid handling the cow more than is necessary, and he should make it a rule to do his work quickly and thoroly. He should never go from a sick to a well cow without first cleansing his hands; neglect of this has resulted in unconsciously carrying

a disease, such as inflammation of the udder, to sound animals. The habit of wetting the hands with milk is filthy in the extreme and should never be practised. A little vaseline may be used on the teats if necessary.

The pail should be held close to the udder, so as to expose the milk to the air as little as possible. The farther the streams fall, and the more they spray, the more dirt and bacteria they collect. Contamination from the foremilk may be avoided by discarding the first few streams drawn, or less than a gill in all. This entails little loss, as the first milk drawn is always poor in butter fat, and if it happens to be badly contaminated, as is frequently the case, much injury and trouble may be saved.

Milkers should be constantly on the lookout for unnatural milk, and when it is discovered it should not be mixt with the rest, but boiled and fed to stock, or thrown away.

V.—HANDLING THE MILK.

Unclean Surroundings and Poor Care.

What has been said about improperly kept stables applies equally, in the main, to an unclean dairy building or room. Milk will not remain pure if stored in an unclean place. One of the chief faults in the care of a dairy room is in allowing it to remain continuously damp, without cleaning. The sloppy methods so often practised are favorable to bacteria.

The care of milk is often sadly neglected. It is not uncommon to see a large can placed in the passageway behind the cows, where it is slowly filled and allowed to remain until the cows are turned out and the chores finished. It may be more than an hour from the time the first milk was drawn until it is cooled. Milk handled in this manner is certain to acquire impurities.

A Good Dairy House or Room.

The location of a dairy house, or room, must be carefully selected. On some farms it is found convenient and not objectionable to have it adjacent to or very close to the stable. It should be placed where it will not be reached by odors from the barnyard, and should be separated from the room in which the cattle are kept by two doors, or situated so it will be necessary to pass out of the stable before entering the dairy room (fig. 7). Special attention must be given to facilities for drainage. It is necessary to carry the waste a considerable distance from the building. An attempt should be made to have the surroundings dry, altho not dusty. The room should be thoroly dried out, in all its parts, at least once a day. If shelves are of wood

they should be kept painted or oiled for greater ease in cleaning. Care must be taken to keep all surroundings clean from fermenting or decaying milk, as well as other forms of dirt; even sour milk ought not to be allowed to remain in the dairy room where there is other milk to be kept sweet.

The inside finish of the dairy house or room should be smooth, to avoid dust-catching places, and it is well to have the floor made of cement or other sanitary waterproof material, which may be carried about a foot up the sides of the room.

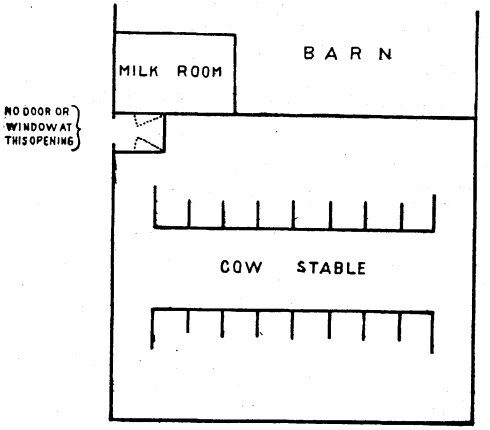

FIG. 7.—A satisfactory arrangement for a milk room when in same building with the cows.

How Milk should be Handled.

Milk must be removed from the stable as soon as possible after it is drawn to avoid germs and characteristic stable odors, which it readily absorbs. Each pail, as soon as it is filled or when the milking of any cow is finished, should be carried to the dairy room. If a dairy house is located at a distance from the stable, the cans should be taken to it as soon as they are filled, and they should not be so large as to require a long time for filling. When there are many milkers and large cans are used, the cans may be carried to the dairy house by suspending them on a skeleton frame between two wheels, or they may be sent across on a cable stretched from the barn to the dairy house.

Straining.—First let it be understood that straining can be expected to remove only the coarser insoluble dirt that falls into milk and a little of the other that has not had time to dissolve before the milk is strained. Much of the dirt that gets into milk is in fluid form or goes into solution almost at once, and straining has no effect on it. Where very great care is taken to produce clean milk, straining is unnecessary except to remove an occasional hair, which escapes even the strictest vigilance. In general practise, however, it seems to be necessary to strain milk to remove dirt—more or less, according to the care that has been exercised.

The sooner milk is strained the better. It should pass thru a metal strainer having a fine mesh and a flannel cloth or cheese cloth folded enough to prevent running thru too fast. Both the cloth and metal strainer ought to be rinsed during a long milking period

to avoid gumming and to wash away fine particles of dirt which might be later broken up and carried thru.

Sometimes the opening of the milking pail is covered with metal gauze or cheese cloth; this may have some value, but it is not as efficient as many persons think. The common strainer pail should not be used in the stable. It offers no special protection to the milk and may even collect dirt that would otherwise be avoided.

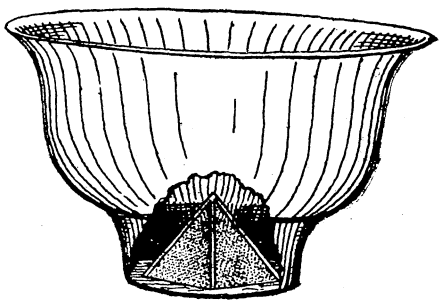

FIG. 8.—Pyramidal strainer.

The common strainer used over cans has flaring sides and a concave bottom, the wire gauze being in the center of the bottom. This only partially serves its purpose. It removes coarse materials, but holds them in the milk stream, and the soft impurities which are easily broken up by agitation and soaking may be forced thru the small openings by the constant current of milk.

Numerous improved forms of strainers are now made, and some of them are very simple and effectively overcome the objection to the old style. In the pyramidal form (fig. 8) the center of the metal gauze is raised and the straining surface is much increased; impurities striking against it work down until out of the current. Others are so arranged that the milk is rising when it passes thru the gauze (fig. 9), and dirt held back falls to the bottom of a settling chamber. A layer of cotton between two pieces of cheese cloth and pieces of wire netting to keep it in place removes many fine particles which escape other materials. Cotton is cheap, and when much milk is handled one can easily afford to use it once and throw it away. Sand and gravel are used as strainers or filters, but special care must be taken to thoroly clean and sterilize them. Filters are also used, the milk being forced thru them by pressure.

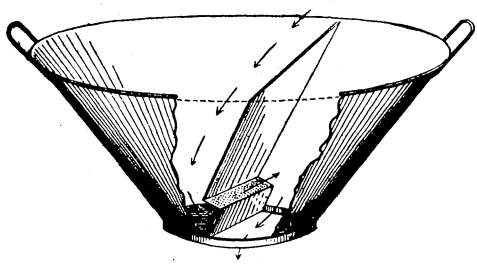

FIG. 9.—Strainer in which the milk is rising as it passes thru the gauze.

When passing thru the strainer large surfaces of the milk are exposed; hence it is important to do this work in a pure atmosphere.

Aerating.—Aeration of milk is its exposure to the air for the purpose of removing "animal odor" or other taint. It is generally

regarded by milk shippers and other handlers of milk as a useful operation. The benefit derived from aeration depends on how much the milk is tainted or "off." The product of a healthy cow, obtained with due regard to cleanliness and feeding, has little or none of the "cowy" or other odor. But it is different when the cow is slightly out of condition, is illy kept, or has been given some strongly smelling food previous to milking, or when the air to which the milk is exposed is laden with odors. Then the odor in the milk is usually strongest when first noticed, and it may be at least partly removed by aeration. On the other hand, it should be remembered that odors caused by bacteria are least noticeable when the milk is fresh and increase when it is held. (See Disinfection, p. 23.)

Milk is said to be "smothered" when it is tightly inclosed in a can immediately after milking without cooling or the removal of the gases which it contains. When thus treated it soon becomes unfit for use. Cans with holes in their lids are used to prevent this trouble, but ventilation is unnecessary if aeration and cooling are practised. All taint should be out of the milk before the lid is put in place.

Aerating does not have a marked effect on the keeping quality of milk; its benefit is in removing undesirable odors. Some persons of sensitive taste can not drink unaerated milk, but relish it when aerated. The operation is done with varying success in several different ways. Usually the milk is cooled more or less at the same time it is being aerated, and it is due to this that its souring is retarded. Actively stirring or agitating milk serves to partially aerate it. A better method is to dip from the can a few quarts and pour it back slowly from a height. This should be repeated many times, depending upon how much taint there is and the quantity of milk; or the milk may be poured from one vessel to another with the same effect. Still more thoro work is accomplished by allowing it to fall thru the air in fine streams or a spray. A milk pail with small punctures in the bottom and held a few feet above a larger receptacle answers for this purpose. Special apparatus is made to operate in the same way.

By other contrivances the air is carried to the bottom of the vessel, whence it rises thru the milk in bubbles, bringing out with it the objectionable gases, until they are mostly removed. This requires from one to five minutes, and is done by a concave plunger or by a pipe and bellows. With the latter arrangement air can be filtered thru cotton to free it from impurities before it is introduced into the milk. Certain aerators are constructed so that the milk passes over them in a thin layer and is thus exposed to the air. These are referred to in connection with cooling.

Here again the necessity of fresh, pure air must be emphasized. It is better to omit aeration entirely than to attempt it in a stable or a dusty or close, foul place. As with other work in the dairy, promptness is necessary in aerating if best results are sought. The aerator should be large enough to care for the milk as fast as it is brought from the cows. Even tho it may be intended to use the morning's milk immediately, it should be aerated the same as the night's milk.

Experiments conducted by private enterprise seem to show that even the strong odor of garlic, which gives so much trouble and causes great losses in certain districts every spring and fall, can be entirely removed by heating milk and aerating it while hot. It is explained that the volatile oil carrying the disagreeable odor is liberated by heat and carried away by the fresh air. This process necessitates the pasteurization of the milk, which is far less objectionable than having a garlic flavor in the butter, and may even be beneficial to the product.

Much taint can be prevented by cleanliness. The so-called "animal" or "cowy" odor is generally to be attributed, not to natural milk, but to the exterior of the cow from which it is taken, or to the unclean person who does the milking, or to filthy surroundings where the milking is done. Aeration is a means of only in part overcoming these neglects.

Cooling.—When milk is intended for cheese or butter making and is to be soon used or promptly delivered at the factory, it may be cooled sufficiently by thoro aeration on the farm. But if it is not at once hauled away or is not to be immediately separated or used for cheese, or if it must be carried a long distance, or is to be used in its natural form as food, fermentation must be checked by low temperature. Cooling is the only important operation in the dairy which should ever be modified, and then only under the conditions named. It is often stated that milk does not require so much care when it is to be used for butter or cheese making as when it is to be sold at retail. This is misleading, as it is true only as far as the cooling is concerned. First-class butter or cheese can not be made from inferior milk. A certain amount of acidity is necessary for cheese or butter making, and this may be allowed to develop partially in the milk before it leaves the farm without harm to the product. Some cheese makers prefer that the temperature never be allowed to go below 60° F.

The lower the temperature to which milk is cooled and held, the longer it can be kept in good condition. It is the custom of some dairymen to serve their customers soon after milking and without first cooling the milk. In such cases it is impossible for it to remain

sweet long, and within a few hours it undergoes more change than milk one or two days old, which had been promptly cooled and kept cool.

It is hardly necessary to emphasize the importance of prompt and rapid cooling when the rate at which germs multiply in warm milk is understood. It is well to cool the milk of one cow while the next is being milked. This is good for the milk, and it saves a tiresome waiting for it to cool after all the milking is completed. It is not sufficient to set a can in a cold room and allow it to cool slowly; this requires several hours and gives time for the germination of spores and the development of bacteria. In order to get full advantage of low temperature the cooling must be completed at the earliest possible moment, and it should be carried down to about 40° F. At temperatures above 40° F. and below 60° F. some species of bacteria grow, but not rapidly as compared with higher temperatures. Milk from dairies where cooling is not practised is frequently sour or tainted when it arrives at the factory; in such cases cooling is the preventive needed, and the labor necessary will be well repaid by the better product.

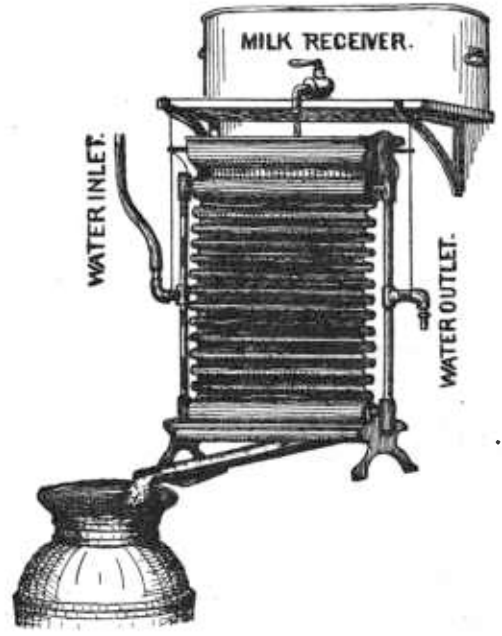

FIG. 10.—Milk cooler for use with running water.

Putting ice into milk or cream, if practised at all, must be done with caution; water is thus added, and there is danger besides of adding many impurities and germs which are not destroyed by freezing.

Cooling is so closely connected with aerating that the terms are often confused. Various kinds of apparatus are constructed for the double purpose of performing both these operations at the same time. These are more satisfactory than setting a can of milk in water and occasionally stirring by hand, altho the latter method is efficient if properly attended to. Milk may be cooled by such contrivances from 30 to 40 degrees in a few minutes. Coolers having a current of water running thru them (fig. 10) at the same time the milk is running over the outside, cool the milk to within 2 to 4 degrees of the

temperature of the water; such thoro work requires several times as much water as the bulk of milk. The best results are obtained when the cooling agent enters the cooler at the bottom and leaves at the top, so the milk is partly cooled before it receives the effect of the coldest water. Where running water is not available, a form of cooler is used which holds a volume of water to which ice has been added (fig. 11). A cooler should be simply constructed, having all parts easily accessible for cleaning.

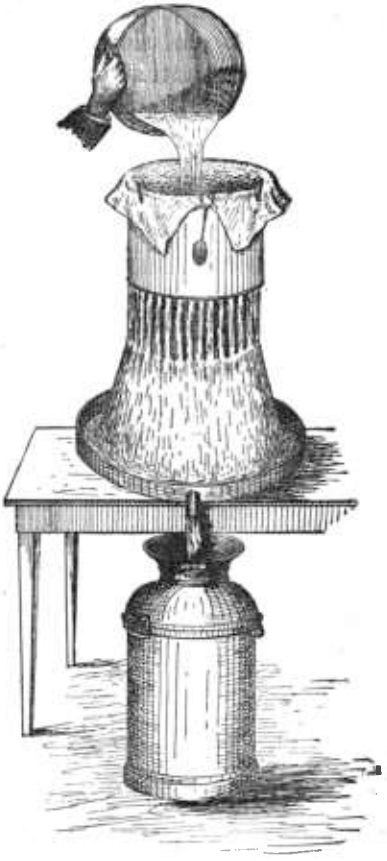

FIG. 11.—Milk cooler for use with a volume of water, not running, and ice.

It is desirable for every dairy farm to have a never-failing cold spring, a good well, or a supply of ice, so that means for cooling milk will always be at hand. If ice is stored near the milk room and the business is large enough to justify the arrangement, a circulation of brine thru pipes below the ice and thru the milk cooler may be arranged, the cold brine being forced about the circuit by a pump. The drippings from the ice may also be used. The cooling of milk should receive the same attention in winter as in summer.

Storing.—A large proportion of the milk delivered to factories is first held on the farm from twelve to twenty-four hours, and sometimes two or three days, and the conditions under which it is stored during this time have an important influence on its quality. Low temperature does not kill bacteria; it only renders them torpid, and they regain their activity as soon as they are again surrounded by warmth; therefore it is as necessary to *hold* the milk at a low temperature as to cool it in the first place. As in cooling, for certain uses of the milk very low temperatures are unnecessary; it should not be allowed to freeze.

The usual way of storing milk is to set the cans in tanks of cold water. Care must be taken to have sufficient water and to have it higher on the outside of the cans than the milk is inside. If the milk is higher than the water, a thin layer on top is not cooled so much as

the rest, fermentation progresses there, and as soon as the can is moved this layer is disturbed and distributes a supply of bacteria thruout the remainder. The tank should be covered to confine the cold air, and when necessary ice should be placed on the cans and in the water. If it is attempted to keep the cans cold by placing blocks of ice on them when grouped on the floor, a blanket should be used to cover them entirely. When delivery is not made for thirty-six hours, as on account of holding over Sunday, the milk should be held at a lower temperature than when delivered within twelve or fifteen hours.

In order to prevent the absorption of odors by milk, the place where it is kept must be free from any objectionable smell. Milk absorbs odors very rapidly. Water in the tanks must be kept sweet by frequent changes. The shelves, walls, and floor must always be clean. Covers of the cans may be left on or off, but if there is any danger of contamination the cans should be closed tightly after the milk is cold. In some dairies where very great care is taken to protect milk from contamination it is a regular and successful practise to bottle and seal the milk before it is cooled, but the cooling is done immediately after the bottling.

Evening and morning milk should not be mixt, especially when the fresh milk has not been cooled. If this is done the whole lot soon spoils. In order to insure the same quality of milk in each can, large tanks are frequently used for mixing all the milk of one milking. This is a matter of some importance when a sample from one can is used for determining the value of the lot, or when the milk is sold at retail.

Preservatives.—The use of preservatives is mentioned at length in Farmers' Bulletin No. 42, U. S. Department of Agriculture, "Facts about milk." Some of them are dangerous to the health of the consumer, and any of them may be harmful if taken regularly in milk. They are prohibited by the national food and drugs act, June 30, 1906, and by some State laws, are condemned by leading authorities, and should not be used.

Shipping.—When milk or cream is shipped, it is sometimes desirable to seal the cans; this may be done by means of a wire passing thru a hole in the edge of the lid and the handle, the ends secured by a lead seal similar to those used on doors of freight cars. The seal presses are sold by dairy-supply firms.

Milk is also sometimes shipped in glass jars in cases, ready to be served to city customers; if properly iced, it does not suffer from exposure to the heat during transit. The jars and packages necessary to carry them are heavy and expensive, but the system has many advantages. Special apparatus are made by which several jars are filled at the same time.

Skimming.—There are great objections to having to care for, and

haul to the factory, a large bulk of milk, when only the cream is needed, and any system which does away with the seemingly useless labor of handling 8 or 10 pounds for the delivery of 1, is most welcome. In the season of bad roads it is difficult to carry large loads of cans, so that at times it is impossible to transport milk to the creamery when cream alone might be carried. Besides it is an advantage to have cream removed on the farm, so that skim milk may be fed when fresh. The gathered-cream system with deep-set milk gives these benefits only partially.

Small separators on the farms of patrons are becoming numerous and are regarded as very advantageous by many. The skimmed milk is thus made immediately available for feeding, and the cream alone needs to be cooled, cared for, and hauled. This system is a natural development and has been widely adopted in some sections of the country and is spreading to others. It does away with the return to the farm of the spoiled contents of a filthy skim-milk tank, as well as the sometimes heated discussions as to how much skimmed milk belongs to the different patrons. But the most important advantage is the use on each farm of its own skimmed milk while fresh and sweet. Besides this, the young stock is protected from taking a disease which may be on a distant farm, whence the germs may be delivered to the creamery and carried away in the skimmed milk to other farms. (See Farmers' Bulletin No. 201, "The cream separator on western farms.")

If the milk is to be set for cream, it should be aerated and set when warm. This should be done as soon as the milk is strained. If a machine is used, aeration takes place while the milk is passing thru the separator. Unless it is desired to ripen the cream immediately it must be promptly cooled.

Hauling.—If milk is sold off the farm, the dairyman's care of it does not cease until he has delivered it to the factory, station, or other destination, and then he has some right to insist that it be properly handled.

Milk should be hauled in spring wagons and the cans filled to prevent churning while on the road. Much trouble is caused by allowing milk to stand an indefinite period on a platform in the heat, waiting for the collector; the storage tank should be placed so it will not be necessary to remove the cans from the water until the wagon is ready to start. A piece of canvas or a blanket thrown over the load protects the cans from dust and extremes of temperature. In hot weather it is an excellent plan to wet the cloth so that the air underneath will be cooled by evaporation. Padded jackets which slip over separate cans and protect the tops and sides are commonly used when cream is shipped in hot weather. Cheap burlap bags of the proper

size, with holes cut for the handles of the cans, may be used to advantage to protect milk from heat during shipment; these covers should be thoroly wet with cold water.

It is doubtful economy to hold milk in warm weather for every-other-day delivery. Some factories require delivery twice a day in the hottest weather. It is important to haul the milk in a clean wagon and to have nothing else in the load that could contaminate it.

Waste products should not be returned to the farm in the same cans used for delivering milk; other vessels should be provided for this purpose. If such hauling is unavoidable, consequent trouble can be reduced by having the skim milk or whey pasteurized or sterilized by boiling, and by keeping the tank clean. Patrons should insist that tanks for waste products be thoroly cleaned daily.

CONCLUSION.

The suggestions on the preceding pages are more or less commonplace, yet it is hoped that by bringing them together in an orderly way they will appeal with renewed force to many milk producers. They have been summarized in various forms. In the original edition of this bulletin there were given "Fifty dairy rules" which covered the entire subject in a general way. These rules were printed separately on heavy cardboard and on cloth, for posting in places where milk was handled. Some authorities have compiled a list of "Don'ts" and others have offered "Dairy commandments."

Recently the writer has proposed a score card, which may be effectively used in judging the sanitary conditions under which milk is produced and handled. These conditions may be marked on a numerical basis the same as good and bad "points" of an animal or a fruit. An important difference, however, is that if a single point in the production of milk is very bad, it has a serious effect upon the finished product, regardless of how much care is taken elsewhere. Accordingly the following score card is so arranged that if one important point scores very low, the dairy will score low, altho the total score may be comparatively high.

Good judgment must be used with this score card as with others. One should be thoroly familiar with the best kind of dairy work to use it most effectively. Of course the greatest difficulty here, as with other score cards, is in deciding just how much to cut for any particular defect. In this it is often an aid to consider the amount of contamination occurring when the point under consideration is in the best possible condition (which should be rated perfect) and when no special care is taken in connection with it (which should be rated 0). The proportion allowed of the perfect score should correspond to the injury the milk is supposed to suffer from the contamination.

Score card for production of sanitary milk.

Date_____ Dairy of _____
No. cows_____ Address_____

		Perfect.	Score.
I. Health of the herd and its protection.	Health and comfort of the cows and their isolation when sick or at calving time.	45	
	Location, lighting, and ventilation of the stable	35	
	Food and water	20	
	Total	100	
II. Cleanliness of the cows and their surroundings.	Cows	30	
	Stable	20	
	Barnyard and pasture.....	20	
	Stable air (freedom from dust and odors).....	30	
	Total	100	
III. Construction and care of the utensils.	Construction of utensils and their cleaning and sterilizing.	40	
	Water supply for cleaning, and location and protection of its source.	25	
	Care of utensils after cleaning	20	
	Use of small-top milking pail	15	
	Total	100	
IV. Employees—Their health, cleanliness, and methods of milking.	Health of employees	45	
	Clean overall milking suits and milking with clean, dry hands.	30	
	Quiet milking, attention to cleanliness of the udder, and discarding foremilk.	25	
	Total	100	
V. Handling the milk.....	Prompt and efficient cooling.....	35	
	Handling milk in a sanitary room and holding it at a low temperature.	35	
	Protection during transportation to market.....	30	
	Total	100	
	Total of all scores	500	

If the total of all scores is—	And each division is—	The sanitary conditions are—
480 or above	90 or above.....	Excellent.
450 or above	80 or above.....	Good.
400 or above	60 or above.....	Medium.
Below 400	Or any division is below 60	Poor.

The sanitary conditions are_____
Scored by_____